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New Interdisciplinary Focus on Polar Regions

by Gunter Weller

The polar regions of the earth have become the focus of considerable attention in recent years in connection with atmospheric pollution and global climate concerns. As examples:

• There is growing evidence that the polar regions play a key role in the physical processes responsible for global climatic fluctuations. In many instances, the polar regions may be the prime source of such fluctuations.

• Polar regions are now widely recognized as important repositories of information on past climates and the causes of past climatic fluctuations.

• There is mounting concern that systematic warming in polar regions will alter the equilibrium of the polar ice masses and in this way affect the global sea level. (continued on page 2)

New Interdisciplinary Focus On Polar Regions *(continued from cover)*

• Induced changes in the chemistry of high-latitude air are viewed with increasing apprehension, based on dramatic trends in ozone depletion.

Field observations and modeling of the polar regions have now revealed the detailed reconstruction of paleoclimates and atmospheric composition from deep ice cores back to 150,000 years B.P.; ozone holes in both polar regions; arctic haze; a possible disintegration of the entire west Antarctic ice sheet, with an associated sea-level rise of 7 m; the role of subarctic glaciers as a major contributor to sea-level rise during the last century; the role of sea ice in feedback processes, amplifying the greenhouse signal at high latitudes; and the warming of permafrost in the Arctic. These findings, underlining the importance of the polar regions in global change, invoke a new awareness of the global importance of the Arctic and Antarctic.

New Impetus for Arctic Research

Arctic research in the U.S. received a new impetus in 1984, with the passage of the Arctic Research and Policy Act. One of the act's purposes is to establish national policy, priorities, and goals, and to provide a federal program plan for basic and applied research with respect to the Arctic including natural resources and materials, physical, biological and health sciences, and social and behavioral science.

Two groups were established by the act: (1) an independent Arctic Research Commission, consisting of five presidential appointees and the director of the National Science Foundation as an ex-officio member, and (2) an Interagency Arctic Research Policy Committee, representing ten federal agencies engaged in research in the Arctic.

The Arctic Research and Policy Act mandates the preparation and biennial update of a five-year U.S. research plan for the Arctic. The commission has emphasized that the basic premise for such a plan should be the development of a comprehensive, interdisciplinary, coordinated approach to the acquisition of the scientific and engineering knowledge required to respond to national needs in the Arctic. These needs include national security and defense, resource development, protection of the environment, and the well-being of the population. The research framework recommended by the commission includes, in order of priority, integrated investigations to understand:

• the Arctic Ocean (including the marginal seas, sea ice, and seabed) and how the ocean and the atmosphere operate as coupled components of the arctic system;

• the coupled atmosphere and land components and how their interaction governs the terrestrial environment; and

• the high-latitude upper atmosphere and its extension into the magnetosphere, with emphasis on predicting and mitigating effects on communication and defense systems.

As a separate regional priority item, research into health, behavioral, and cultural problems related to the arctic environment in Alaska was also recommended.

Interdisciplinary Science Plans

The first five-year arctic research plan mandated by the act was produced by the Interagency Arctic Research Commission in 1987. Nine areas were covered in detail: ice dynamics, weather, and climate; marine ecosystems; energy and mineral resources; land environments; coastal processes and engineering; health; social science; data, information, and logistics; and international cooperation.

Approximately $90 million are spent annually by federal agencies on arctic research, with the Department of Defence, the Department of the Interior, the National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA) the four largest contributors, in that order.

Recommendations for necessary programs were developed based on a review of the National Research Council (NRC) Polar Research Board's (PRB) report on national issues and research priorities and on other NRC and agency documents. The PRB identified about a hundred major planning documents with recommendations on research emphasis in the Arctic, written over a ten-year period prior to 1985. Most of these dealt with single disciplines only, and few were truly interdisciplinary.

The urgency for better interdisciplinary coverage emerges with the concept of the International Geosphere-Biosphere Programme (IGBP) and global change. A joint U.S.-Canadian plan has been outlined (see article, page 12). For the Antarctic, the Scientific Committee on Antarctic Research will address an Antarctic IGBP plan at a meeting in Hobart, Australia, in September 1988 (see article, page 13). A position paper written by the PRB emphasizes four areas of concern:

• detection of changes of global importance best observed in Antarctica;

• processes linking the Antarctic ice to the global ocean and atmosphere;

• Antarctic sources of paleoenvironmental information; and

• ecology in the changing Antarctic environment.

Problem Areas

The proposed new interdisciplinary studies in the polar regions require that manpower, research facilities and laboratories, data management systems, and logistics be in place before they can begin. The U.S. has a well-established Antarctic program but has only begun to think of itself as an arctic nation (as noted in the January 1988 report of the Arctic Research Commission entitled, *Entering the Age of the Arctic: Opportunities and Obligations of an Arctic Nation*).

According to a research profile published by the Arctic Environmental Information and Data Center of the University of Alaska, there are over a hundred U.S. universities engaged in research in the Arctic. NSF lists 86 institutions, not all of them universities, that were funded by NSF to do arctic research in FY86 and FY87. While most of these researchers work quite independently of each other, a newly formed Arctic Research Consortium of the United States may pull some of the researchers together to foster joint ventures (see article below).

Major new research facilities are now being established in the Arctic. The joint NASA–University of Alaska Synthetic Aperture Radar Facility is one example (see article, page 10). A workshop was held in March 1988 to address arctic data issues (see article, page 9). The Interagency Arctic Research Policy Committee now publishes a journal, *Arctic Research of the United States,* that will inform researchers and managers alike about new arctic research (see box, page 16). A major logistical deficiency that remains is the lack of a dedicated ice-capable arctic research vessel, a need that is on the agenda of several federal agencies.

Political obstacles to international cooperative research in the Arctic are also beginning to crumble. In a remarkable speech delivered in Murmansk in October 1987, General Secretary Gorbachev called for coordinated research in the Arctic and setting up an international arctic scientific committee. The recent joint summit statement by President Reagan and General Secretary Gorbachev includes a paragraph on "arctic contacts and cooperation." The international committee is now being established and the first major international scientific conference on the Arctic is planned in Leningrad, 12–16 December 1988. It seems that the "Age of the Arctic," as envisioned by the Arctic Research Commission, has arrived.

Dr. Weller is Professor of Geophysics at the University of Alaska–Fairbanks and chairman of the National Research Council's Polar Research Board.

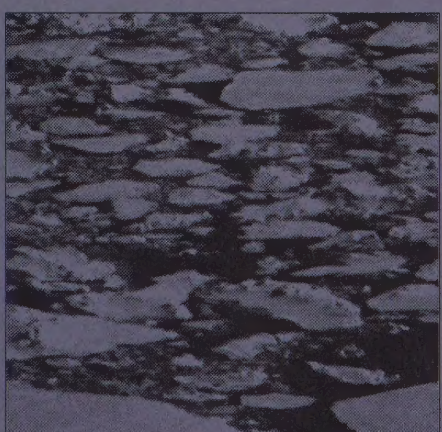
Arctic Research Consortium of the United States (ARCUS)

A workshop was held in Boulder, Colorado, on 18–19 January 1988 to establish an organization known as the of Arctic Research Consortium of the United States (ARCUS). Prospective members are universities and nongovernment organizations conducting research in the Arctic concerned with geosciences, biosciences, medicine, socioeconomics, and engineering. A prospectus and a set of bylaws have been prepared. They define a consortium dedicated to issues related to an overall enhancement of the quality and posture of research conducted by nongovernment institutions in the United States. Key issues are improved educational opportunities, curricula, student mobility, information exchange, logistics, and the development of interinstitutional partnerships in the conduct of interdisciplinary research programs according to the guidelines and priorities recently established by the Arctic Research Commission. To these ends, the consortium will strive to act as an open forum to develop new ideas, approaches, and an ongoing discourse with federal and state agencies supporting research in the Arctic.

The group gathered in Boulder selected Luis Proenza, vice chancellor for research and dean of the Graduate School at the University of Alaska–Fairbanks, to act as chair. Working with him as the Steering Committee of ARCUS are Mark Meier of the University of Colorado, Boulder, and Norbert Untersteiner of the University of Washington, Seattle.

The basic criterion for membership in ARCUS is substantial involvement in arctic research. The membership structure will include institutional memberships for representatives from all interested universities in the United States, international institutional memberships, and invited associate memberships recognizing arctic scientists not included in member institutions.

The first full meeting of the consortium will take place during the annual meeting of the Arctic Division of the American Association for the Advancement of Science — the 1988 Arctic Science Conference — on 7–10 October 1988 in Fairbanks, Alaska. For more information contact Proenza, Dean, Graduate School, University of Alaska–Fairbanks, AK 99775-1720, USA.



Summer Antarctic sea ice in the marginal ice zone.

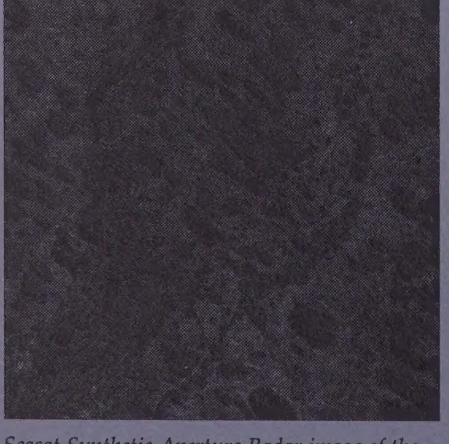
A University Profile

The Institute of Arctic and Alpine Research at the University of Colorado, Boulder

by Mark F. Meier

One of the intellectual challenges of global change is developing new mechanisms for understanding the many coupled and interlinked processes that drive the earth system. Centers, institutes, and departments are being created in several universities to attempt to provide this essential cross-fertilization of the disciplines. Yet there are difficult problems to overcome. Courses of study as well as peer recognition and rewards are based on success in an individual discipline, and to step outside that discipline involves new territory where the goals and rewards are uncertain. A few organizations have been exploring this territory for some years; one of these is the Institute of Arctic and Alpine Research (INSTAAR) at the University of Colorado in Boulder.

INSTAAR is an interdisciplinary research institute that emphasizes the environmental, physical, and biological sciences as they pertain to high altitudes and high latitudes and to former cold environments. Some members of INSTAAR are rostered faculty of the University of Colorado; others are primarily involved in research programs. Graduate students supervised by INSTAAR members are registered for advanced degrees in the academic department most closely related to their research interests. Strong emphasis is placed on providing graduate students with an interdisciplinary atmosphere and on close contact with faculty, both on campus and in the field.



Seasat Synthetic Aperture Radar image of the Alaskan North Slope showing numerous elongated lakes in the permafrost.

The "total" approach — an appreciation of the whole, through an integrated study of some of the parts and the interactions between those parts — supports INSTAAR's particular role in the study of the earth's extreme environments. It's mission is closely related to the Global Change Program. INSTAAR's research covers some of the most sensitive and important regions on earth, such as the Arctic. It also provides the historical perspective necessary for analyzing future environmental change.

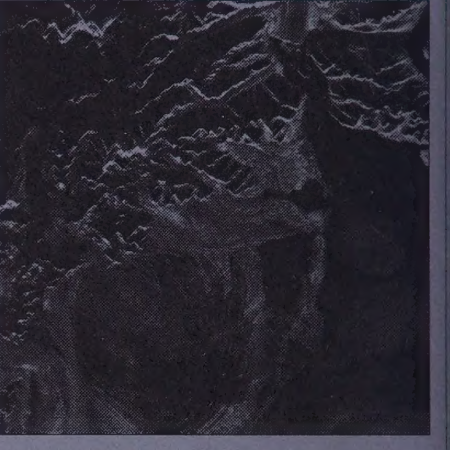
Research fields emphasized at INSTAAR include:

• Ecology of Cold Regions. Plant and animal ecological research aims to further our understanding of the response of the ecosystems to change, both natural and man-made, and the interactions between the geosphere and the biosphere.

• Processes of Cold Regions. Studies are made of glacier dynamics, glacier and ice-sheet reconstructions, snow hydrology, avalanches, pollutant deposition and subsequent movement through snow and plants, periglacial processes, climatology, and similar topics.

• Paleoecology of Cold Regions. Biological indicators in upper Quaternary terrestrial and marine records are collected throughout the Arctic and the alpine zone to provide information on past environments, in order to place future environmental changes into perspective.

• Geochronological Research. INSTAAR's Center for Geochronological Research includes faculty with expertise in the development of dating techniques and the use of these methods to derive information about environments of the past. Fundamental research and the application of multiple techniques to specific problems in an interdisciplinary context are stressed.



Seasat Synthetic Aperture Radar image of the Malaspina Glacier in Alaska. Curved bands are associated with its surging flow.

The Mountain Research Station operated by INSTAAR is located in the Rocky Mountains 40 km west of Boulder at 2,880 m. This research site offers year-around access to the alpine tundra of Niwot Ridge up to 3,750 m, as well as to the montane and subalpine forest. Niwot Ridge is a National Science Foundation sponsored Long-Term Ecological Research site. Many interesting comparisons can be made between the ecology of alpine permafrost tundra of Niwot Ridge and that of the Arctic.

INSTAAR publishes *Arctic and Alpine Research*, a quarterly interdisciplinary journal devoted to original research papers submitted by an international authorship, as well as a series of occasional papers.

For information contact Dr. Mark F. Meier, Director, INSTAAR, Campus Box 450, University of Colorado, Boulder, CO 80309, USA.

The Geophysical Institute at the University of Alaska–Fairbank

by Syun-Ichi Akasofu

The Geophysical Institute at the University of Alaska in Fairbanks, has long been interested in studying the earth as a system that extends from the surface of the sun to our planet's interior. The specifics of the research program are guided by the advantages of its location at a high geographic and geomagnetic latitude and along the tectonically active Pacific Rim; the Arctic is in its backyard, and the auroral oval dominates the night sky.

The genesis of the Geophysical Institute came from the efforts of two physics professors at the Alaska Agricultural College and School of Mines. V.R. Fuller and E.H. Bramhall received a grant from the Rockefeller Foundation in 1929 to establish the means for studying the height of the aurora. In effect, their work also established that the Fairbanks area, with its embryonic college, was an ideal location for studies of high-latitude phenomena. For the International Polar Year of 1932–1933, the now-University of Alaska was designated a first-order station in the network engaged in seismological, geomagnetic, and electric potential measurements, auroral investigations, and study of the ionosphere.

World War II brought more studies, including auroral effects on radio waves, geomagnetic disturbances, and auroral light intensity variations. Since much of the program had important scientific merit, the university continued with geophysical work for various federal entities after the war. Through Alaska's territorial delegate to Congress, the university campaigned for funds to establish a permanent Geophysical Institute devoted to natural science in the far North; the campaign was successful, and the institute was formally established on 1 July 1949 by an act of Congress.

The early years of the institute were guided by men of foresight and skill, such as Christian T. Elvey, director from 1952 to 1963, and Sydney Chapman, scientific director from 1951 to 1970, who made the Geophysical Institute a center for the successful International Geophysical Year at the close of the 1950s. The institute's midyears produced strengthened programs in atmospheric sciences and solid-earth geophysics, from seismology to volcanology, and added work in glaciology and permafrost studies to complement the already powerful research program in auroral studies. The present institute is an institution with the breadth to address a full suite of geophysical questions.

The research conducted at the institute is roughly divided into five disciplines: space physics, aeronomy, atmospheric sciences, ice physics, and solid earth physics. However, there are many continuing and planned interdisciplinary studies among these. Naturally, most scientists are interested in global aspects of geophysical phenomena, with particular emphasis on the polar region. The atmospheric sciences group and the ice group are working on atmosphere sea-ice interaction studies; the aeronomy group and the atmospheric sciences group are planning a spectroscopic study of ozone; an atmospheric scientist is working closely with the solid-earth group in studying the effects of volcanic eruptions on climate; ice scientists are attempting to understand changes in the temperature-depth profile in permafrost in terms of climate changes. Multidisciplinary research is also underway with the Institute of Marine Science at the university in studying the Gulf of Alaska as an interactive system of the atmosphere, the Pacific Ocean, and the Alaskan glaciers.

In support of its research program, the Geophysical Institute operates several facilities. Among the more significant are the Poker Flat Research Range, the only university-owned research rocket range in the world, and the Alaska Synthetic Aperture Radar (SAR) Facility, the only such SAR receiving and analysis station in the United States (see article, page 10).

The Arctic is one of the least explored areas on earth; it offers an infinite variety of fascinating opportunities for research. The polar upper atmosphere provides the most challenging problems in space physics and aeronomy; the arctic region significantly controls climatic changes and, in its ice sheets and permafrost, stores records of past climates. Colleagues, especially young physicists and geophysicists with pioneering spirit, are encouraged to join in these endeavors.

For further information contact Dr. Syun-Ichi Akasofu, Director, Geophysical Institute, University of Alaska–Fairbanks, Fairbanks, AK 99775–0800, USA.

Seasat SAR image of the Yukon River flowing southwest. The Brooks Mountain Range lies to the north, the White Mountains to the south. Spatial resolution of the image is 150 meters.

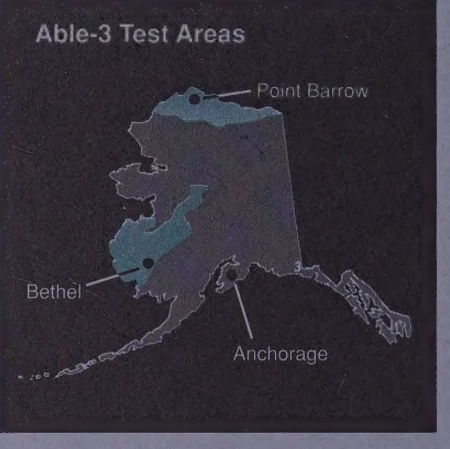
The NASA Global Tropospheric Experiment: Arctic Boundary Layer Expedition (ABLE-3)

The goals of the National Aeronautics and Space Administration's Tropospheric Chemistry Program are to develop an understanding of global tropospheric chemistry and assess the susceptibility of the global atmosphere to chemical change. A major component of the program is the Global Tropospheric Experiment (GTE), which consists of (1) a series of field expeditions to evaluate the performance of instrumentation under development and (2) specific field measurement issues relevant to global tropospheric chemistry.

The thrust toward instrumentation development is called the Chemical Instrumentation Test and Evaluation (CITE). GTE/CITE-1 focused upon carbon monoxide (CO), nitric oxide (NO), and the hydroxyl radical (OH), while CITE-2 investigated techniques for the measurement of nitrogen dioxide (NO_2), nitric acid (HNO_3), and peroxyacetyl nitrate (PAN).

The second and parallel thrust of GTE is focused on atmospheric boundary layer experiments and is known as GTE/ABLE. The ABLE series of expeditions has the following general scientific objectives: (1) understanding the processes that regulate the uptake and release of trace gases by surface ecosystems, with particular emphasis on obtaining an improved understanding of factors that influence tropospheric trace gas budgets at the global scale; (2) determining the distributions of photochemically active atmospheric gases in relation to both source and sink characteristics and meteorological transport processes in regions that have been identified as high-priority areas for understanding global tropospheric chemistry; and (3) developing new approaches for using airborne measurements, integrated with ground and satellite support data, to move toward quantification of atmospheric chemical processes at increasingly larger spatial scales. ABLE-1 was an investigation over the tropical Atlantic Ocean, and ABLE-2A and 2B were expeditions over the tropical rain forests of the Amazon Basin of Brazil during dry and wet seasons respectively.

The third expedition in the ABLE series (ABLE-3) is investigating biosphere-atmosphere gas exchange processes in arctic tundra and subarctic boreal environments, and the atmospheric photochemical and transport processes that couple these environments to the global tropospheric chemical system. The project is focused on high-latitude (50°N) Northern Hemisphere regions that



have been shown to be especially sensitive to climatic change. The research is specifically focused on the sources, sinks, and distributions of methane (CH_4), CO, carbon dioxide (CO_2), NO, NO_2, other nitrogen gases (NO_y), HNO_3, PAN, ozone (O_3), selected non-methane hydrocarbons, and organic acids.

ABLE-3 experiments include aircraft survey measurements, airborne- and tower-based determinations of vertical fluxes for selected trace species, and ground-based measurements of surface exchange processes. ABLE-3 is also studying the potential role of soil carbon in arctic and boreal peatlands as a source and/or sink for CH_4 and CO_2 under present and future climatic conditions. It will also provide an assessment of the factors that influence atmospheric photochemical processes in the high latitudes during summer.

The initial expedition, GTE/ABLE-3A, was conducted in Alaska during July-August 1988. Airborne measurements were conducted out of Barrow and Bethel, Alaska, on the NASA Electra research aircraft, a four-engine turboprop especially fitted for tropospheric chemistry investigations. The aircraft provides access to the range of peatland environments typical of the northern high latitudes, e.g., over the coastal wet tundra from Point Barrow north of the Brooks Range and over subarctic deltaic to interior peatlands of the Yukon Delta from Bethel to Galena. Extensive ground-based measurements were conducted at a remote site northwest of Bethel. Initial efforts are underway in formulating a joint U.S.-Canadian follow-on expedition, ABLE-3B, for the summer of 1990, for similar studies in the boreal forest and subarctic peatland regions of Canada. The following were specific science objectives for ABLE-3A:

• Surface-atmosphere gas exchange studies focusing on three subject areas: the characterization of the subarctic and arctic peatlands as significant sources of atmospheric CH_4, the role of the high-latitude biosphere and ocean as a source and/or sink for atmospheric CO_2, and the role of open water and vegetated terrestrial surfaces as sources and/or sinks for O_3, NO, NO_2, NO_y, and other photochemically active molecules.

• Studies of trace gas distributions focusing on two subject areas: (1) the exchange of gases between surface sources and sinks, the mixed layer, and the free troposphere, and (2) the role of long-distance transport as a source of O_3, or O_3 precursors, to the arctic troposphere, with special attention to the question of external sources of pollution during summer conditions.

Other exploratory studies were carried out. One was to explore trace gas variability in the atmospheric boundary layer related to major arctic surface types with measurements across coastal wet tundra, open Arctic Ocean, and polar ice-pack boundaries. Another was to study the chemical characteristics of atmospheric haze layers resulting from biomass burning.

There were two major components of the ABLE-3A ground studies: (1) flux measurements using chamber tech-

niques and (2) flux and ambient concentration measurements using a micrometeorological tower. The chamber methods give information on the smallest scales to identify the climatological factors that influence emission and deposition rates. The micrometeorological techniques provide flux information for larger areas.

The ground-based enclosure studies and associated ecological measurements were partially supported by the NASA Global Biospherics, Interdisciplinary, and Terrestrial Ecosystems programs. These studies complement ongoing research sponsored by the National Science Foundation at Long Term Ecological Research sites in Alaska.

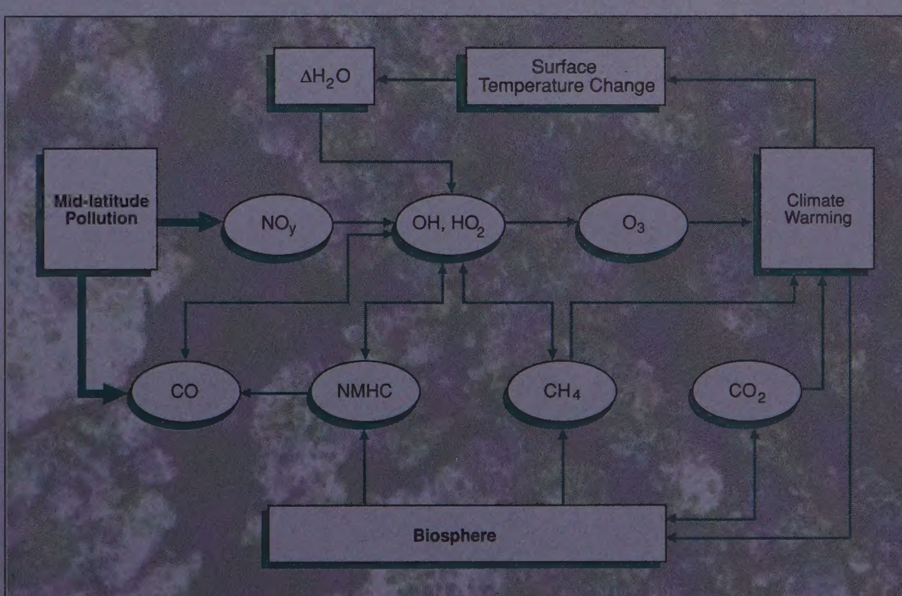
The airborne measurements focused on photochemical and surface exchange processes over major arctic and subarctic wetland regions and on land-ocean-ice gradient studies. Atmospheric photochemical processes, involving active species like CO, NO, NO_2, NO_y, HNO_3, and O_3, were investigated on all flights. These missions also used a continuous lidar remote sensing of aerosol and O_3 distributions above and below the aircraft to identify specific atmospheric structures. Missions to study surface exchange processes were conducted under clear weather conditions with two primary sampling strategies. The characteristics of sources and sinks and transport of gases from the surface to the free troposphere were investigated with repeated vertical soundings from 150 m to 5 km altitude over the complete research area.

In addition to measurements over peatlands during surface exchange studies, other missions documented the chemical characteristics of major air masses originating over the north Pacific Ocean and over the Arctic. These flights used detailed meteorological data to document the dynamical evolution of the air masses selected for chemical characterization. Studies of these relatively pristine air masses prior to their transit over the industrialized regions of North America complemented studies of sources and impacts of regional pollution in North America.

ABLE-3A transit flights between Wallops Island, Virginia, and Alaska were used to characterize latitudinal and longitudinal gradients in the distribution of trace gases in the free troposphere. In addition, remote sensing of aerosol and O_3 above and below the aircraft provided a continuous two-dimensional view of chemical-dynamical interactions in the entire tropospheric column along the flight path. Transit flight data documented trace gas chemistry across a major pollution gradient from eastern North America to the Arctic. Also, during the period of the ABLE-3A transit flights, biospheric CO_2 sinks and CH_4 sources were near maximum, and these flights were designed to test the predictions for CO_2 and CH_4 distributions that have been made using a NASA three-dimensional model.

Collaborating and cooperating agencies in Alaska included: in Barrow, the Ukpeagvik Inupiat Corporation's National Arctic Research Laboratory and the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Monitoring for Climatic Change group; in Bethel, the U.S. Fish and Wildlife Service and the Kuskokwin Community College; in Anchorage, the NOAA National Weather Service and the U.S. Geological Survey; and the University of Alaska–Fairbanks. Principal investigators for the ground-based measurements were from Harvard University; State University of New York–Albany; University of North Carolina; University of Delaware; University of New Hampshire; TGS Technology, Inc.; University of Maine; Woods Hole Oceanographic Institution; Aerodyne Research, Inc.; and the NASA Langley Research Center. Principal investigators for the airborne measurements were from the Georgia Institute of Technology, University of California–Irvine, Harvard University, the Brazilian Space Agency (INPE), NASA Ames Research Center, NASA Langley Research Center, and ST Systems Corporation. The overall expedition management has been overseen by the GTE Project Office at NASA Langley Research Center.

For additional information contact Robert C. Harriss or James M. Hoell, Jr., Mail Stop 483, NASA Langley Research Center, Hampton, VA 23665-5225, USA. The program manager for GTE is Dr. Robert J. McNeal, NASA Headquarters, Code EEU, Washington, D.C. 20546, USA.



Atmospheric chemistry and biosphere interactions associated with climatic warming in the Arctic.

Arctic Drilling

Knowledge of the Arctic Ocean is more than of regional importance in that the area is also linked to the evolution of the adjacent oceanic basins and continents. An understanding of past and present plate movements in the Arctic will be required before a complete model of late Mesozoic and Cenozoic Northern Hemisphere plate motions can be achieved. These motions and the structure, paleontology, and paleoenvironment of the Phanerozoic sedimentary rock sequences of the circumpolar regions and the continental shelves assume additional importance in oil and gas exploration.

Today's polar oceans represent unique environments because of their cold hydrospheres and because of the ice caps on adjacent land masses. These environments are the combined product of a long-term climate change since the end of the Mesozoic and of short-term, recurring climate shifts between late Cenozoic glacials and interglacials. Studies of the marine depositional environments and sediments of the polar oceans that record this evolution have provided important but fragmentary data to describe the onset of the cold polar climate since about 26 million years ago and the response of fauna and flora to the cold temperatures. Virtually nothing is known of the transition period.

The evolution of the cold hydrospheres has also had a tremendous impact on the hydrography of the world's oceans because as the surface waters of the polar oceans cool, they sink and flow toward the equator to fill all major deep-sea basins. The climatic evolution in the polar regions is therefore global in impact for both the responses and dynamics of the world's ocean and atmosphere and for the biosphere. To trace this evolution from its probable onset in the late Mesozoic to the present is a first-order geoscientific problem that can only be solved by studying the history of the polar oceans. The sediment record of the Southern Oceans is quite well known from long piston cores and drill samples from the Deep Sea Drilling Project (DSDP). The Arctic, however, is much less well known.

Background
Scientific drilling of the ocean floor began in 1968 with the DSDP, using the drill ship *Glomar Challenger*. In 1985, a second generation of ocean drilling began with the Ocean Drilling Program and the *JOIDES* (Joint Oceanographic Institutions for Deep Earth Studies) *Resolution*. Until now, sea ice has prevented drilling in the Arctic Ocean. An assessment of currently available technology indicates that it is feasible to commence scientific drilling in the Arctic.

Interested nations have formed an ad hoc group of scientists who in the next few months expect to organize a steering committee with subcommittees for technology and science. Active nations are Norway, the Federal Republic of Germany, Sweden, Denmark, Canada, and the U.S.

Initially, a systematic program will begin to compile existing data. Researchers will then fill data gaps by conducting comprehensive airborne, shipborne, and ice-station geophysical and geological surveys including the collection of piston cores and shallow cores (core lengths of 200 m or less from single entry holes). The program will be international, with participation open to all interested nations.

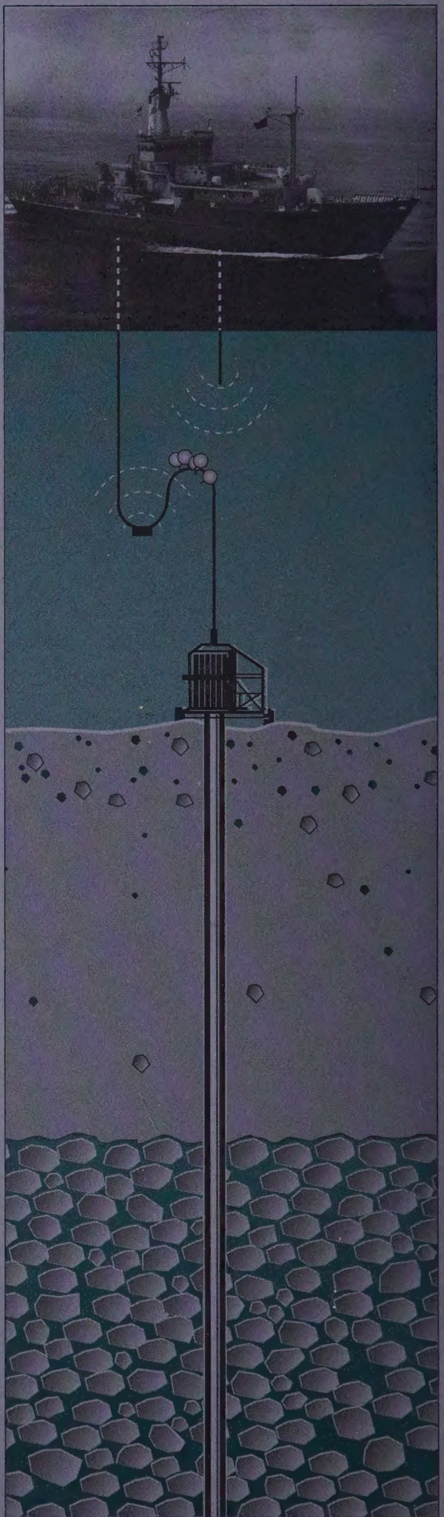
Scientific objectives include:

• characterization of preglacial arctic deep-sea paleoenvironments;

• timing and characteristics of initial climatic cooling and glaciation;

• timing, magnitude, and periodicity of high-amplitude late Cenozoic climatic oscillations and resultant ice sheets;

• paleooceanographic and paleontologic response (both flora and fauna) to climatic change, warm-cold oscillations, and changes in the depth and width of corridors linking arctic and global oceans.



Proposed shallow drill system, with a 50 m capability, being deployed in ice covered waters.

• structure and nature of the Alpha Ridge, Chukchi Plateau, Lomonosov Ridge, Yermak Plateau, Morris Jesup Plateau, and Nares Strait lineament;

• structure and development of arctic continental margins; and

• paleogeography and paleobathymetry of the Mesozoic and Cenozoic Arctic.

In order to address the scientific issues, long cores (at least 200–300 m in length) are required. The problems of arctic drilling and the attendant site surveys are not trivial and will pose a significant challenge. There are however, certain options:

• Utilize an ice island, such as Hobson's Choice or multiyear floating sea ice, suitably thickened and smoothed as a platform.

• Utilize an existing drilling ship frozen into the ice pack to drift passively or be repositioned, and drill specific targets. This approach is likely to be too expensive to be practical.

• Use *JOIDES Resolution* for drilling at selected Beaufort and Greenland Sea sites.

• Utilize a research vessel such as the Canadian Class 8 icebreaker with icebreaking and drilling capability to sample selected sites.

• Initially utilize a Gatling gun core approach to obtain samples of all lengths up to 50 m (see illustration).

Site selection will pose a problem. One approach would be to use a sea-ice camp to obtain seismic reflection data in the vicinity of previous geophysical surveys.

The establishment of a manned scientific station from which the drilling operations can be carried out will doubtless attract many investigations from other disciplines which will profit from the logistics of the drilling operations. One might anticipate "piggyback" programs in arctic marine biology dynamics, physical and chemical oceanography, auroral studies, glaciology, and ice and ship engineering.

Innovative thinking and F. Nansen's courageous personal effort led to the construction of the famous polar research vessel *Fram*. It has been proposed that arctic deep-sea drilling be carried out in celebration and honor of the centennial of this singular event. The program would be known as the Nansen Centennial Arctic Program (NCAP). It is planned for 1993–1996 and will represent a daring international and interdisciplinary effort to carry out research in the Arctic.

Arctic Environmental Data Workshop

Under the auspices of the Interagency Arctic Research Policy Commission, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the National Science Foundation, and the U.S. Geological Survey cosponsored a workshop in Boulder, 21–24 March 1988. Approximately 60 participants attended from Canadian and U.S. government agencies and universities.

The purpose of the workshop was to consider steps to be taken to establish an arctic environmental data system. To facilitate discussion, the question was divided into four parts:

• how to create an on-line and hard copy arctic environmental data directory;

• identification of steps that interested organizations (U.S. and Canadian government and non-government) can and should take to create a system;

• technological problems and solutions associated with the development of such a data system; and

• identification of key arctic environmental parameters that should be monitored for the purpose of studying global and arctic mesoscale change.

The workshop participants agreed that a successful arctic data system would have to accomplish three purposes:

• be coordinated with and contribute to efforts to establish a data system in support of other national and international programs related to global environmental change;

• support the study of arctic marine and terrestrial mesoscale ecosystems, such as the Bering Sea; and

• be useful to arctic scientists, residents and resource managers.

The additional question of how real-time data needs can be coordinated with scientific research needs was raised but not fully discussed.

The final report of the meeting is available. Questions and requests for copies may be directed to Thomas L. Laughlin by calling (202) 377-8196 or by writing him at Room 5811, Department of Commerce, 14th and Constitution, Washington, D.C. 20230, USA.

The Alaska SAR Facility

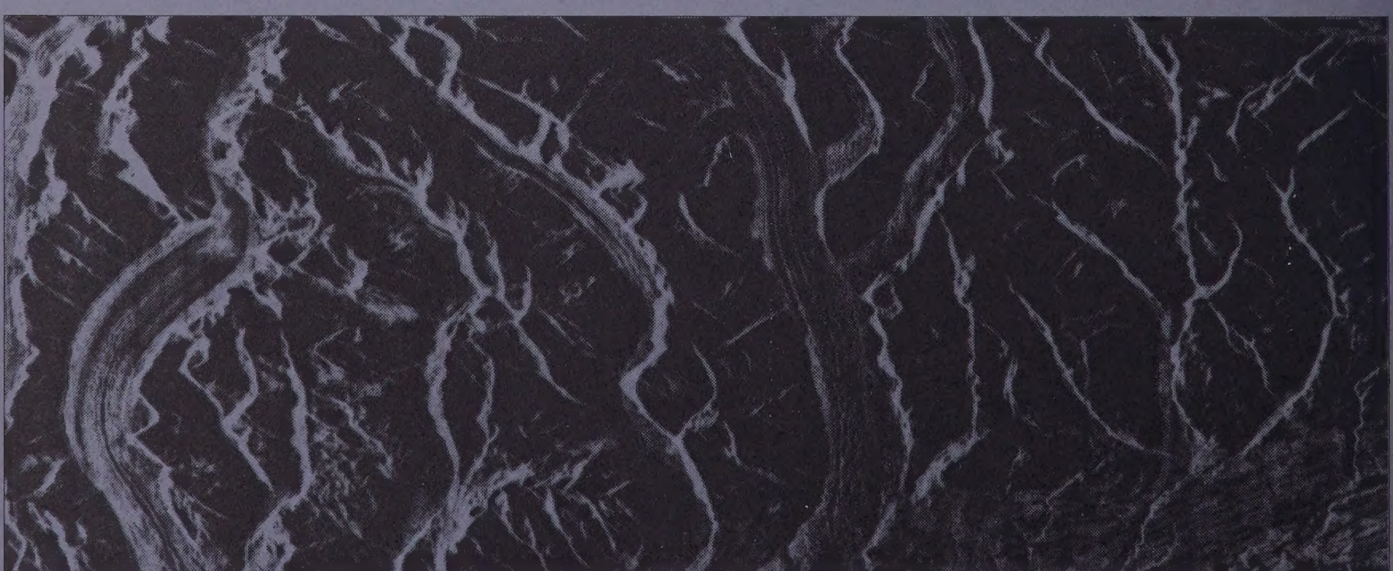
When one thinks of the worlds's arctic regions, an image of a vast, remote, sparsely populated, often inhospitable area comes to mind, a region shrouded in clouds in summer and in darkness and frigid cold in winter. Although this image is only partially accurate, it is perhaps not surprising to learn that, even in the age of satellite remote sensing, the observational data base on the state of the earth's surface in this portion of the globe is extremely limited. This is a limitation that the Alaska Synthetic Aperture Radar (SAR) Facility has been created to alleviate by obtaining and analyzing all-weather, high-resolution radar imagery of this region.

SAR is a technique by which a high-resolution radar image is produced by numerically synthesizing the equivalent of a very large antenna while, in fact, using a small antenna. Unfortunately this means being forced to deal with a data stream of such a magnitude that it exceeds the capacity of current space-capable tape recorders. To receive data from the Arctic, stations must have a line-of-sight view of the satellite while it views the region of interest. SAR systems are particularly qualified to provide information on the world's great sea-ice packs. The distribution and internal behavior of these ice-packs will be profoundly influenced by climatic warming through a strong positive feedback: as air temperature warms, ice cover decreases with enhanced heat transfer from the warm ocean to the atmosphere, which causes a further increase in the air temperature. The Alaskan SAR Facility (ASF), is a station designed to provide an all-weather radar view of a circular region with a radius of 2,000 km centered on the receiving site at the Geophysical Institute at the University of Alaska–Fairbanks (UAF).

The ASF program is a joint NASA/UAF program that will downlink, process, analyze, and provide SAR imagery and geophysical information to the research community dealing with arctic and global research problems. The satellites involved include the European Space Agency ERS-1 (launch 1990), the Japanese ERS-1 (launch 1992), the Canadian Radarsat (launch 1994), and ultimately NASA's Earth Observing System (Eos, launch late 1990s). It is also possible that ASF will downlink and process limited quantities of high-resolution multispectral scanner data obtained by a system on the Japanese ERS-1. As both Japanese ERS-1 and Radarsat are scheduled to carry tape recorders that will store SAR data, images can then be obtained from sites anywhere on the globe. The ASF receiving, processing, and archiving systems are being developed at the Jet Propulsion Laboratory in a cooperative program with UAF. This program is very ambitious in that it attempts to significantly advance SAR technology and serve as a steppingstone to the multifrequency, multipolarization systems proposed for Eos. Of particular interest is the development of a geophysical processor system that will extract information from this imagery related to ice displacements, ice type distributions and wave states, and the establishment of an archiving system that ultimately will allow the user to view low-resolution images of particular data sets on his or her home computer.

Although the most clear-cut applications of the ASF data are to investigations of sea-ice behavior, the data will also be useful in a wide variety of other fields including oceanography, glaciology, geomorphology, vegetation studies, and structural geology.

Readers interested in obtaining more information on the ASF program should write Dr. Gunter Weller, Alaska SAR Facility, Geophysical Institute, University of Alaska–Fairbanks, Fairbanks, AK 99775-0800, USA.



Seasat SAR image of Alaska Range showing Elridge Glacier (center).

The U.S., with other nations, has long pursued scientific research on the Antarctic continent. The success of the International Geophysical Year (1957–1958) led to the 1961 Antarctic Treaty, which reserves the region for peaceful purposes and encourages international cooperation in research and other concerns. High-level U.S. government reviews of Antarctic policy have repeatedly supported the treaty and cooperative scientific research for the solution of worldwide and regional problems. In 1970 the president said the "Antarctic is the only continent where science serves as the principal expression of national policy and interest." Current policy, set forth by the president in a 1982 memorandum, is that "the United States Antarctic Program should be maintained at a level providing an active and influential presence in Antarctica designed to support the range of U.S. Antarctic interests. This presence shall include the conduct of scientific activities in major disciplines; year-round occupation of the South Pole and two coastal stations; and availability of necessary logistics support."

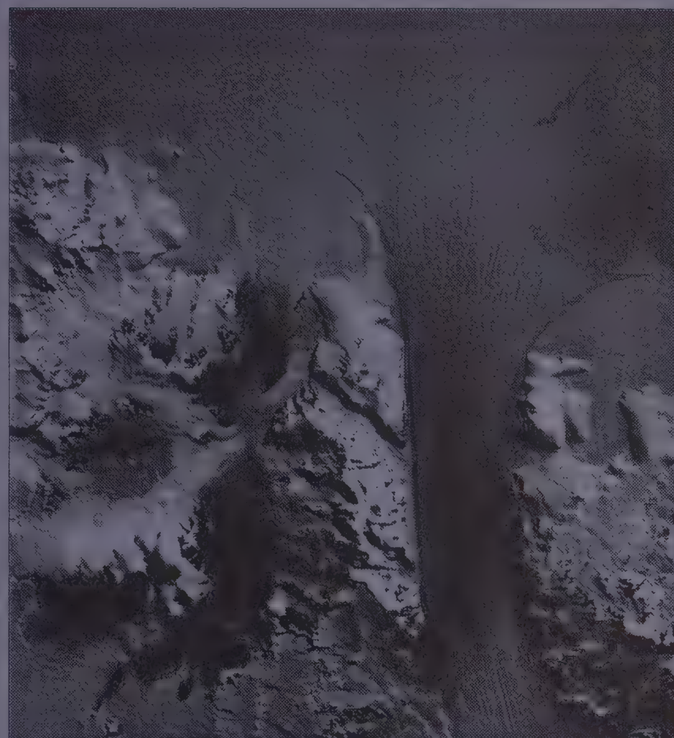
Funding and management for science and support is consolidated at the National Science Foundation, which funds university research and federal agency programs related to Antarctica and draws on logistical support capabilities of government agencies (on a cost reimbursable basis) and of contractors.

Today the U.S. Antarctic Program funds some 80 research projects a year in the disciplines of astronomy, upper atmosphere physics, meteorology, glaciology, geology and geophysics, the ocean sciences, biology, and medical research.

In addition to granting funds for research, the program provides scientists with logistical and operational support in the Antarctic. The support includes a year-round inland research station at the South Pole (90° S latitude), two year-round coastal research stations (McMurdo at 78° S and Palmer at 64° S), summer camps as required for research, the ice-strengthened research ship *Polar Duke*, a fleet of LC-130 airplanes (ski-equipped C-130s), Twin Otter airplanes when required, UH-1N helicopters, an icebreaker for channel breaking, and a variety of oversnow vehicles. Ships of the U.S. academic fleet and the ocean drilling program also support research in the Antarctic on occasion.

Access to Antarctica is generally seasonal. Other than activities at the year-round stations, most research projects are planned for the austral summer.

Air transport between New Zealand and McMurdo is provided several times per week in the austral summer from early October to the end of February. From McMurdo, the logistics hub, science parties in summer have access as required to other sites including the station at the South Pole. Several flights are made in August between New Zealand and McMurdo, providing one opportunity each year for winter access to that station. Between February



Landsat image of Byrd Glacier, Antarctica, flowing through the Transantarctic Mountains into the Ross Ice Shelf.

and October the summer camps are closed, and winter research is limited to the immediate environs of the South Pole and McMurdo, where station residents are isolated for as long as eight months.

Palmer Station, on Anvers Island by the Antarctic Peninsula, is logistically isolated from the rest of the program and relies mainly on *Polar Duke* (during or between research cruises) for transport to a port at the southern tip of South America. The ship makes several trips throughout the year. The U.S. Antarctic Program is developing air access in cooperation with the U.S. Air Force and Chile, and this service will increase the frequency of access to Palmer. *Polar Duke* provides onboard research support in marine biology, oceanography, and geophysics, and can support shore parties in the Antarctic peninsula region.

The estimated fiscal 1988 U.S. expenditure for research in Antarctica is $34,501,754. Of this, $13,500,000 is in direct awards of funds to institutions and $21,001,754 is for science support (e.g., operation of laboratories) provided in Antarctica.

For further information contact Guy G. Gutheridge, Division of Polar Programs, National Science Foundation, 1800 G Street NW, Washington, D.C. 20550, USA.

Arctic Interactions

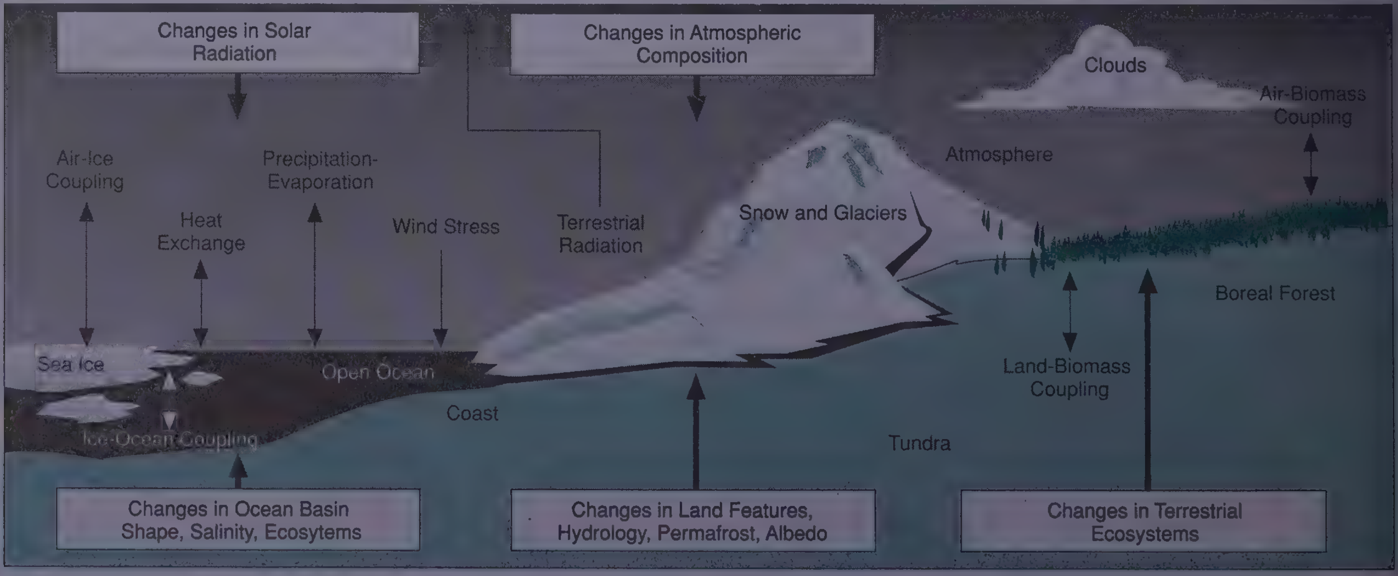
The vast reaches of the Arctic, embracing much of Alaska, Canada's Northwest Territories, Greenland, northern Scandinavia, Siberia, and the Arctic Ocean, define one of the most extreme environments on the planet, where limited sunlight, extreme temperature excursions, and a short growing season impose harsh constraints on terrestrial and marine ecosystems. Sea ice, snow cover, glaciers, tundra, permafrost, boreal forests, and peatlands are each a sensitive indicator of global change, susceptible to subtle variations in sunlight, surface temperature, ocean heat transport, air and ocean chemistry, and the particulate loading of the atmosphere. These circumstances, and the essentially unexploited character of much of these far northern lands, identify the Arctic as a bellwether of global change and a zone of early warning for the effects of global greenhouse warming that now seems certain to characterize the earth in coming decades. The Arctic, for these reasons, will of necessity assume a special importance in the International Geosphere-Biosphere Programme (IGBP).

Polar lands and oceans are more than passive indicators of change in the coupled earth system: high-latitude air-ice-ocean interactions play an important role in determining regional and global climate and deep ocean circulation patterns; arctic air-land interactions — particularly those involving peatlands and permafrost — involve potentially important sources and sinks of trace gases and of elements key to life. Biological activity in arctic lands and in the euphotic zone of the Arctic Ocean may link orbitally induced variations in insolation, global carbon dioxide abundance, and surface temperature. Pole to equator temperature differences fix the basic circulation patterns of the global atmosphere.

A series of workshops held in Boulder in 1987 and organized by the Office for Interdisciplinary Earth Studies (OIES) in cooperation with the Institute of Arctic and Alpine Research of the University of Colorado and the Royal Society of Canada explored the interactions that link physical, chemical, and biological elements of the arctic system, with the goal of defining critical areas of study for an arctic component of the IGBP. A resulting publication, *Arctic Interactions*, is now available as an OIES Report — drawn from the contributions of 47 participants from the U.S. and Canada representing the fields of oceanography, atmospheric physics and chemistry, geology, glaciology, marine and terrestrial ecology, and solar-terrestrial physics.

Scientific problems and research needs are defined for 13 areas: nutrient flux, carbon storage, biological communities and ecosystem dynamics, hydrology, permafrost, snow and glaciers, coastal processes, sea ice, ocean circulation and bottom water formation, atmospheric dynamics and heat balance, atmospheric composition, solar and geomagnetic impacts, and the record of environmental change. Also included are discussions of satellite systems, geobiosphere observatories and transects, research methods and the arctic environment, and data and information management. A summary section defines eight underlying multidisciplinary themes as particularly compelling: (1) response of arctic terrestrial and freshwater systems to change; (2) role of arctic peatlands in biogeochemical cycling; (3) biota in relation to the ocean-ice margin; (4) arctic glacier and ice sheet effects on sea level; (5) the hydrologic cycle in the Arctic; (6) chemistry and dynamics of the arctic atmosphere; (7) arctic ocean/sea-ice/atmosphere interactions; and (8) the arctic paleoenvironmental record.

A copy of *Arctic Interactions* may be obtained by contacting OIES/UCAR, P.O. Box 3000, Boulder, CO 80307-3000, USA.



Major components, inputs, and interactions of the arctic ecosystem.

Antarctic Interactions

A plan drafted by the Polar Research Board (PRB) outlining a recommended Antarctic component of the IGBP will be considered by the International Council of Scientific Union's Scientific Committee on Antarctic Research (SCAR) at their 20th meeting in Hobart, Tasmania, in September. The PRB serves as the U.S. National Committee to SCAR. Cited in the plan are a number of phenomena and processes in the Antarctic region which have a potentially important role in global change.

• The Antarctic region has a high negative radiation budget and so acts as one of the world's "refrigerators." Any changes in the budget of heat will perturb atmospheric and oceanic circulation on a global scale.

• Antarctica provides unique conditions for investigating the impact of man-made pollutants on atmospheric ozone.

• Conditions beneath the Antarctic ice shelves and the girdle of sea ice promote the formation of bottom water that drains northward to cool the global ocean.

• A detailed record of past environmental change extending over hundreds of millennia is preserved within the Antarctic ice sheet.

• Because climate change is predicted to be largest at high latitudes, early detection of such change should be sought in the polar regions.

• The Antarctic ice sheet contains enough water to raise the global sea level some 70 meters. Greenhouse climate warming is bound to deplete the volume of this ice.

Although steady progress is being made on some of these issues, others are not sufficiently addressed. To this end SCAR scientists will recommend a considered set of high-priority elements for an Antarctic component of the IGBP that builds on existing efforts and fills gaps, emphasizing important processes and interactions that link various components of the Antarctic system. Four interdisciplinary research themes are identified in the early planning document: (1) the early detection and study of climatic and environmental changes of global importance; (2) study of processes linking Antarctic ice to the global ocean and atmosphere; (3) use of paleoenvironmental information sequestered in Antarctic ice sheets to provide a context for interpreting current climatic changes against the background of the past 160,000 years of environmental change; and (4) study of ecological changes in the evolving Antarctic environment, to assess the interactions between climate and Antarctic biota.

To obtain a copy of the report contact W. Timothy Hushen, Polar Research Board, National Academy of Sciences, 2101 Constitution Avenue, NW, Washington, D.C. 20418, USA.

Calendar 1988-1989

Oct 4-6 World Wildlife Fund's Conference on Consequences of the Greenhouse Effect for Biological Diversity, Washington, D.C. Contact Conference Coordinator, 1250 Twenty-Fourth Street, NW, Washington, D.C. 20037, USA.

Oct 20-26 Twenty-Second International Symposium on Remote Sensing of the Environment, Abidjan, Ivory Coast. Contact Alan Parker, ERIM, P.O. Box 8618, Ann Arbor, MI 48107-8618, USA.

Oct 24-28 ICSU IGBP Scientific Advisory Council, Stockholm, Sweden. Contact Thomas Rosswall, Executive Director, IGBP, Royal Swedish Academy of Sciences, Box 50005, S-104 05, Stockholm, Sweden.

Oct 31-Nov 3 Geological Society of America (GSA) Annual Meeting: Centennial Celebration, Denver, Colorado. Contact Jean Kinney, GSA, P.O. Box 9140, Boulder, CO 80301, USA.

Nov 7-10 World Congress: Climate and Development, Hamburg, Federal Republic of Germany (FRG). Contact Prof. Dr. Dieter Otten, Deutsches Institut zur Erforschung der Informationsgeselischaft (DII), An der Blankenburg 64, Postfach 1660, D-4500 Osnabruck, FRG.

Nov 28-Dec 2 POLMET 88 - Asia and Pacific Regional Conference: Pollution in the Metropolitan and Urban Environment, Hong Kong. Contact POLMET 88 Secretariat, c/o Hong Kong Institution of Engineers, 9/F, Island Centre, No. 1, Great George Street, Causeway Bay, Hong Kong.

May 10-19 International Association of Hydrological Sciences Third Scientific Assembly: Symposium 8 (S8)—Remote Sensing and Large-Scale Global Processes, Baltimore, Maryland. Contact Ivan Johnson, Chairman, TSA Organizing Committee, 7474 Upham Court, Arvada, CO 80003, USA.

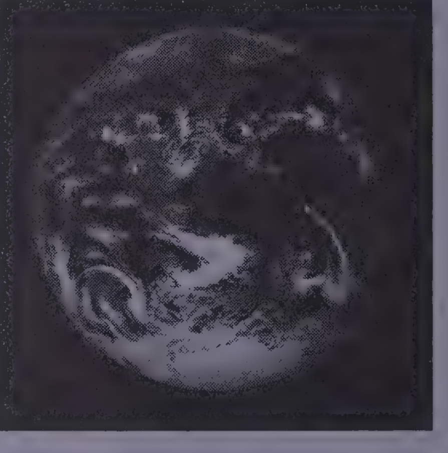
July 9-19 Twenty-Eighth International Geological Congress, Washington, D.C. Contact Secretary General, B.B. Hanshaw, P.O. Box 1001, Herndon, VA 22070-1001, USA.

July 31-August 11 International Association of Meteorology and Atmospheric Physics (IAMAP) Fifth Scientific Assembly, Reading, United Kingdom. Contact Ross Reynolds, IAMAP 89 Organizing Secretary, Department of Meteorology, University of Reading, 2 Earley Gate, Whiteknights, Reading RG6 2AU, United Kingdom.

Global Change Program Updates

The International Geosphere-Biosphere Programme (IGBP): Towards a Plan for Action

The planning for an International Geosphere-Biosphere Programme (IGBP) is moving towards an event which will probably be the most crucial in the development of the International Council of Scientific Union's (ICSU) new program to address global change. The Scientific Advisory Council of the IGBP is scheduled to meet 24–27 October 1988 in Stockholm, Sweden. It will involve national IGBP committees, national as well as scientific ICSU members, and other key bodies involved in relevant international scientific research cooperation (e.g., the United Nations Educational, Scientific, and Cultural Organization; the United Nations Environment Programme; and the World Meterological Organization). The main item on the agenda is the discussion of a major report on the IGBP, which has been prepared by the Special Committee for the IGBP (SC-IGBP).



As earlier reported in *EarthQuest*, the SC-IGBP established four coordinating panels to develop proposals for research components of the IGBP, and four working groups to address issues that will cut across all research components of the program. Most of these eight groups have met at least once since their establishment in July of 1987 and reports have been prepared on the basis of those meetings. An editorial committee of the IGBP met at the time of the first OIES Global Change Institute in Snowmass, Colorado, in mid-August. Their report describes a plan of action for the next phase of the development of an IGBP, based on the discussions of the SC-IGBP and on input from the eight groups.

Apart from an outline of an IGBP based on the coordinating panel and working group reports, the document discusses the IGBP in relation to other international research programs contributing to an understanding of the earth system. There are several related programs which are essential for such an understanding, e.g., the World Climate Research Programme, the Joint Global Ocean Flux Study, and the International Global Atmospheric Chemistry program. The relationships between these activities and the IGBP must be addressed in order to ensure efficient interactions.

National IGBP committees will play a crucial role in the development of an IGBP as well as during implementation. At present there are 25 national groups established to coordinate planning for national input to the IGBP. Of special note is the active involvement of developing countries. When Sir John Kendrew, president of ICSU, wrote to national ICSU members asking them for voluntary financial contributions to the planning phase of the IGBP, the first positive responses were received from Bangladesh and Jamaica. The following nations have established national committees or ad hoc groups and are, according to the IGBP constitution, committed to contribute to the financing of the international planning and coordination: Austria, Australia, Bangladesh, Belgium, Canada, Chile, the People's Republic of China, the Republic of China, Colombia, Czechoslovakia, Egypt, France, the German Democratic Republic, the Federal Republic of Germany, Hungary, India, Israel, Jamaica, Japan, the Netherlands, Poland, Portugal, South Africa, Sweden, Switzerland, the United Kingdom, the United States, and the Union of Soviet Socialist Republics.

It is expected that a number of other national committees will be established shortly. The SC-IGBP will make a special effort to secure involvement from as many nations as possible, as a wide international participation in the IGBP is a prerequisite for its success. The active involvement of the member unions of ICSU is also essential, and IGBP committees have been established by several ICSU bodies.

On the basis of the discussions at the IGBP Scientific Advisory Council meeting in October, it is envisaged that the membership of the coordinating panels and working groups will be expanded with the charge to develop detailed plans for an IGBP. These plans should be ready by early 1990, at which time the international implementation phase is expected to begin. More than 15 IGBP meetings are now planned in 1989 to consider various aspects of the IGBP. Specific research projects with clear objectives, standardized methodology, proper evaluation procedures, and mechanisms to achieve synthesis and integration need to be developed in many areas of research.

The IGBP secretariat at the Royal Swedish Academy of Sciences (Box 50005, S-104 05 Stockholm, Sweden) is issuing a report series. The first three issues contain the report to the ICSU 1986 General Assembly from the ad hoc planning committee for IGBP and the reports from the first two meetings of the Special Committee (Paris, July 1987; Cambridge, MA, February 1988). The fourth report, which will be available in mid-September, is the planning report to be presented to the IGBP Scientific Advisory Council. These reports are available upon request from the IGBP secretariat. In addition, a newsletter is also planned.

NAS/NRC Committee on Global Change

The U.S. Committee on Global Change (CGC) is in the final stages of preparing its report on initial research priorities for the U.S. contribution to the International Geosphere-Biosphere Programme (IGBP). The report recommends that the initial U.S. contribution focus on a limited number of key questions that are essential to improving scientific abilities to predict global change: How is the climate system coupled to the dynamics of terrestrial ecosystems and, specifically, what are the feedbacks between ecosystem dynamics and the hydrologic component of the climate system? What factors control fluxes of radiatively active gases between the land and atmosphere and fluxes of biologically important elements from land to aquatic systems? What are the feedbacks between climate change and fluxes of these materials? What are the fluxes of biogenic substances from the upper ocean to both the atmosphere and deep ocean? How do these fluxes affect climate, and how does climate change affect these flux rates? What data can the record of the past provide that can be used to validate global change models? What future scenarios of land use change and industrial activities can be developed based on available documentation of the recent period of intensive human interaction with the earth system?

The CGC plans to establish panels to develop detailed research plans to address each of these questions. Clearly, the U.S. component of the IGBP will encompass a broader range of research activities as it develops. These areas for initial focus are not intended to delimit the scope of the program. Rather, they are intended to fill current gaps that the CGC believes must be addressed to understand global change. The CGC's report will be carried forward to the international meeting of the Scientific Advisory Council for the IGBP, to take place in Stockholm on October 24-27 (see article, page 14). The U.S. delegation to Stockholm will include members of the CGC, the foreign secretary of the National Academy of Sciences (NAS), representatives of federal agencies, and National Research Council (NRC) staff. Throughout the development of the report, the committee has worked closely with representatives of federal agencies, primarily through the interagency Committee on Earth Sciences.

This dialogue has led to agreement on the overall framework for the U.S. Program on Global Change and the broad categories in which agency contributions to the program can be defined. As part of an effort to increase public awareness of global change issues, the CGC is organizing a public forum on global change to be held in Washington, D.C., in the spring of 1989 in collaboration with the Smithsonian Institution and National Geographic Society. The primary objective is to bring to the general public a balanced view of the nature of global change and the emerging scientific view of the earth as a system—with neither alarmism nor complacency. The forum will embrace the whole Western Hemisphere through involvement of Canada, Latin America, and the Caribbean. A steering committee to guide the organization of the forum has been formed. In support of the goal for the IGBP to understand the earth as a system, the committee is also developing proposals for bilateral research on global change. Three areas of research are being pursued with the People's Republic of China: the joint definition and development of an exemplary geobiosphere observatory; collaborative process studies in the wind and water transport of soils; and collaborative process studies in climate-vegetation interactions. Proposals for cooperative research with the USSR are also being developed under the joint agreement between the two Academies.

The above discussion illustrates the broad range of disciplines relevant to global change issues, more than can be practically involved in the usual NRC committee process. To get the vital input from these communities that are not adequately represented through normal membership, the CGC is instituting a system of corresponding members. These members will be kept informed and have input to CGC activities, and attend CGC meetings. The following disciplines, for example, would be represented through this process: hydrology, soil science, agriculture, geography, economics, conservation biology, plant pathology, ocean chemistry, geophysics, upper atmospheric studies, and human health.

The CGC is chaired by Harold A. Mooney, Stanford University. Other members include D. James Baker, Joint Oceanographic Institutions, Inc.; Francis P. Bretherton, University of Wisconsin; Kevin C. Burke, Lunar and Planetary Institute; William C. Clark, Harvard University; Margaret B. Davis, University of Minnesota; Robert E. Dickinson, NCAR; John Imbrie, Brown University; Thomas F. Malone, St. Joseph College; Michael B. McElroy, Harvard University; Berrien Moore III, University of New Hampshire; Ellen S. Mosley-Thompson, Ohio State University; and Paul G. Risser, University of New Mexico. The U.S. members of the ICSU Special Committee for the IGBP—John A. Eddy, UCAR; James J. McCarthy, Harvard University; and S.I. Rasool, NASA Headquarters—serve as ex officio members, as does Robert E. Sievers, University of Colorado, who represents the NRC Commission on Physical Sciences, Mathematics, and Resources (CPSMR). The committee will next meet on 9–10 November 1988, Washington, D.C.

John S. Perry and Ruth S. DeFries provide staff support for the CGC at the National Research Council, 2101 Constitution Avenue, NW, Washington, D.C. 20418, USA.

EarthQuest
Summer 1988

Arctic Research of the United States

Arctic Research of the United States is for people and organizations interested in learning about U.S. government-financed arctic research activities. It is published by the National Science Foundation on behalf of the Interagency Arctic Research Policy Committee and in cooperation with the Arctic Research Commission.

Arctic Research contains:

- reports on current and planned U.S. government-sponsored research in the Arctic;
- reports of meetings of the Interagency Arctic Research Policy Committee and the Arctic Research Commission;
- summaries of other current and planned arctic research activities, including that of the Alaska, local governments, the private sector, and other nations; and
- a calendar of forthcoming local, national, and international meetings.

The emphasis in *Arctic Research* is on summary and survey articles covering research rather than on technical reports, and the articles are intended to be comprehensible to a non-technical audience. Although the articles go through the normal editorial process, manuscripts are not refereed for scientific content or merit since the journal is not intended as a means of reporting scientific research. Articles are generally invited and are reviewed by agency staffs and others as appropriate.

The journal will be initially published twice annually; one will be devoted to summaries of U.S. government programs of the previous fiscal year and the other to non-government reports. A subscription to the journal is free.

To obtain a subscription write the Coordination and Information Section, Division of Polar Programs, Room 620, National Science Foundation, Washington, D.C. 20550 USA, or call 202/357-7817.

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Note from the Editor: To allow for this expanded issue on polar research we have combined the spring and summer issues of *EarthQuest*.

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